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(71) Applicant  
Siemens  
Aktiengesellschaft  
Berlin and Munich, Ger-  
man Federal Republic.  
(72) Inventors  
Ingrid Hanke  
Peter Jiru  
Erich Ross  
(74) Agents  
G. F. Redfern & Co.

**(54) Manganese-zinc ferrites**

(57) A high or medium-permeability, low loss, calcium containing manganese-zinc ferrite with a given initial permeability temperature coefficient that is constant and positive or only fluctuates by a small amount around zero over a wide temperature range, has the following basic composition:-

49 to 55 mol % Fe<sub>2</sub>O<sub>3</sub>  
0.2 to 5 mol % (SnO<sub>2</sub> and/or TiO<sub>2</sub>)  
remainder to 100 mol % MnO and ZnO combined with 0.03 to 0.4% by weight of CaO and a very small amount of CoO, in particular 0.02 to 0.5% by weight of CoO, the amount of CoO being chosen to match the theoretical Fe<sup>2+</sup>-content level, which is controlled by the proportion of Sn, Ti and extra-stoichiometric iron present, in such a way that the desired temperature coefficient of the initial permeability  $\mu_i$  is obtained.

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Fig.1

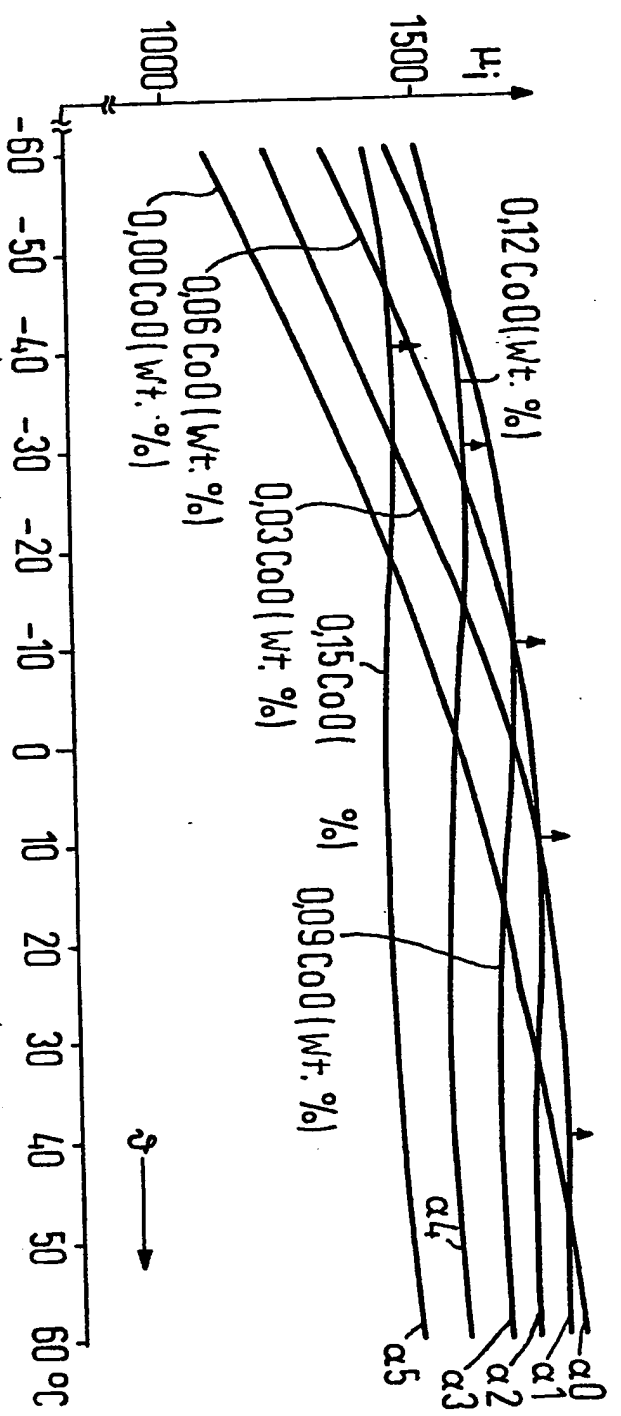
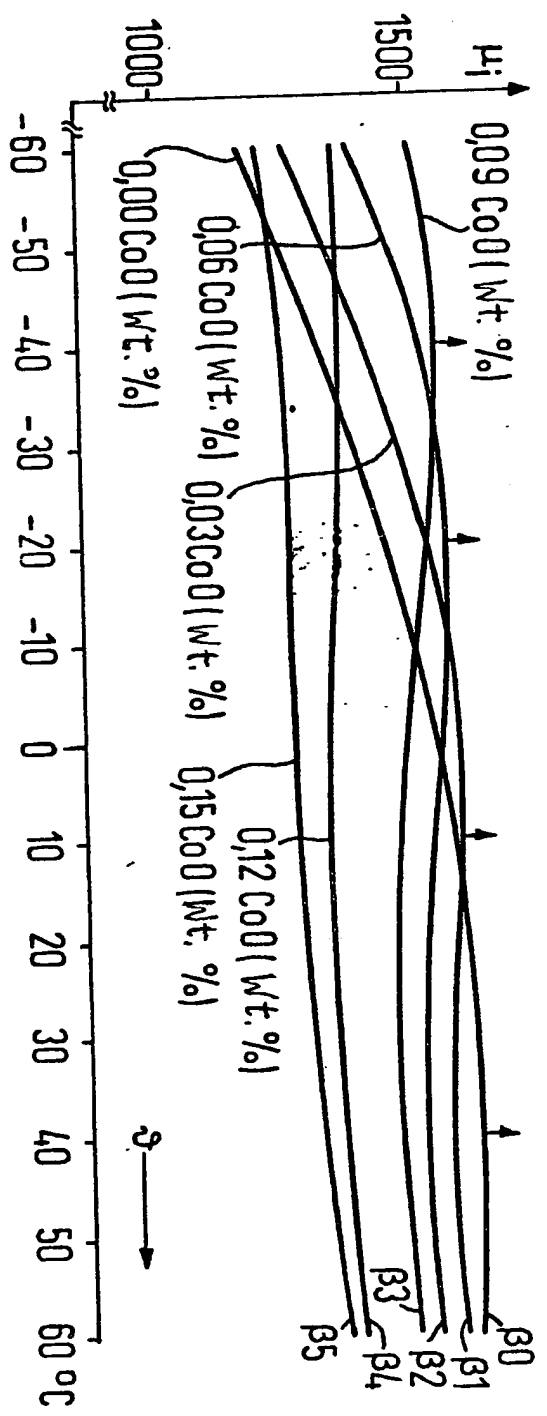
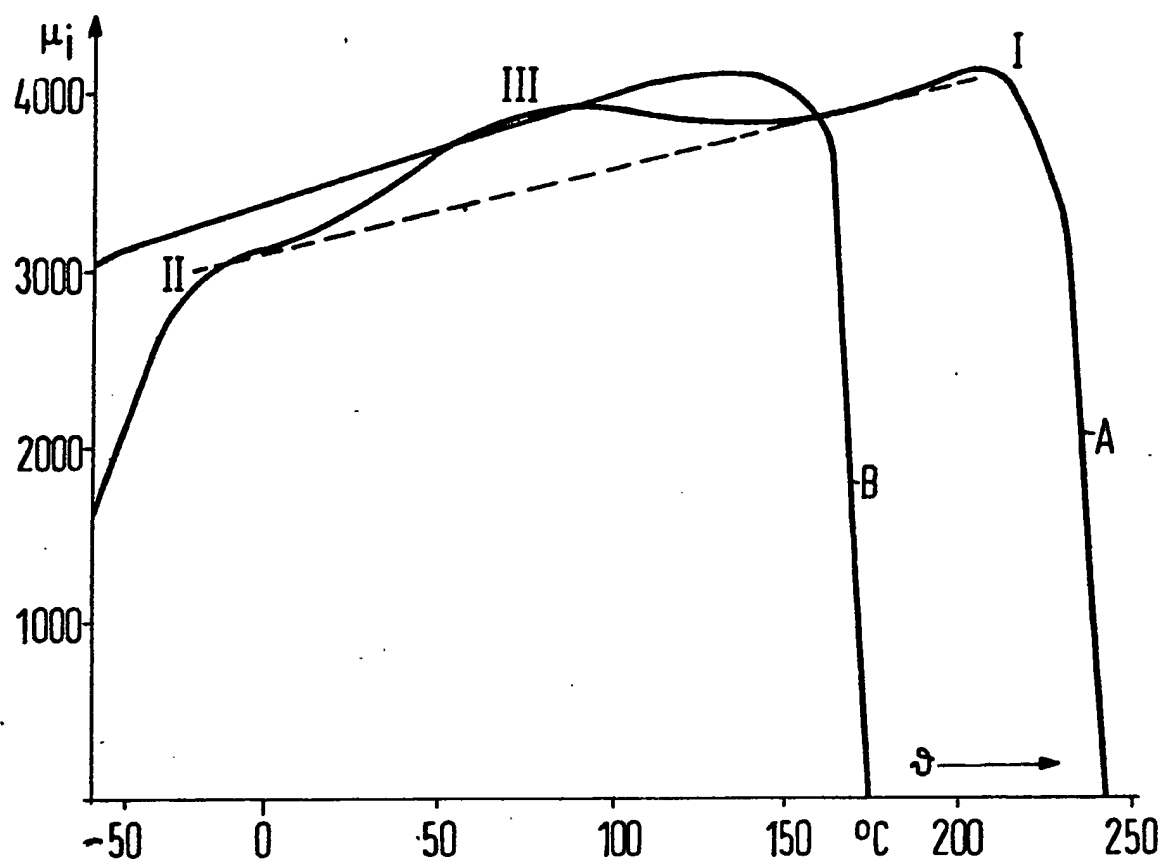


Fig.2



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Fig.3



## SPECIFICATION

## Manganese-Zinc ferrites

- 5 The present invention relates to manganese-zinc ferrites and to methods of producing them for the proper functioning of inductance coils in filter circuits comprising an inductance and a capacitance, the most important property of the inductive component, apart from quality, is the temperature coefficient of initial permeability of the material of the core which is usually a ferrite material. The temperature coefficient of inductance, which must be inversely related to that of the capacitance of the filter, determines the variation in frequency caused by the frequently inevitable temperature fluctuations, in accordance with the equation: 10

$$\omega \delta = 1 / \sqrt{L_0 (1 + \alpha_L \Delta \theta) \cdot C_0 (1 + \alpha_C \Delta \theta)}$$

- 15 where  $L_0$  and  $C_0$  denote the inductance and capacitance respectively at  $0^\circ\text{C}$ ,  $\alpha_L$  is the temperature coefficient of inductance and  $\alpha_C$  is the temperature coefficient of capacitance.

- Only when  $\alpha_L(\theta) = -\alpha_C(\theta)$  can the filter frequency be kept approximately constant, i.e. the value maintained  $\omega$  approximately equal to  $\omega_0$  where  $\omega_0$  is the frequency at the set temperature with the values  $L_0$  and  $C_0$  ( $0^\circ\text{C}$ ).  
20 In addition, ferrite materials having a temperature coefficient that only fluctuates around zero by a small amount are also of interest for filters, e.g. for use in oscillation circuits with mica capacitors for wide temperature ranges, e.g. in portable equipment, where  $\alpha_L \approx \alpha_C \approx 0$ . The initial permeability/temperature curve of manganese-zinc ferrites and therefore the associated losses of medium and high permeability ferrites depend upon magnetic saturation temperature response and upon the temperature effect of various energy parameters which are determined by the crystal anisotropy energy, magnetostriction and so on. By 25 selecting suitable formulations and sintering conditions, these relationships can be so controlled that so-called secondary permeability maxima or bends occur in the  $\mu(\theta)$  curve in certain temperature ranges. As a result, it is possible to obtain small, roughly constant temperature coefficients in certain temperature ranges above these singularities.

- 30 Thus, for example, by means of the  $\text{Fe}^{2+}$ -ion component of the ferrite lattice, the crystal anisotropy energy can be influenced, a specific amount of  $\text{Fe}^{2+}$ -ions being needed to lower the crystal anisotropy energy to zero at a specific temperature. The lower this temperature has to be (it is only above this zero point that the temperature coefficient is adequately small and satisfactorily controllable and the losses, particularly the hysteresis losses, are low) the more  $\text{Fe}^{2+}$ -ions have to be present in the ferrite lattice. The  $\text{Fe}^{2+}$ -ion component in the ferrite lattice can be controlled in two different ways, namely: 35  
(1) through the total iron content, because any part of the total iron ions which is in excess of an initial formulation of 50 mol %  $\text{Fe}_2\text{O}_3$ , becomes divalent when the ferrite is formed, because of charge neutrality (theoretically  $\text{FeO} \cdot \text{Fe}_2\text{O}_3$  is formed), and  
(2) as is described in German Patent Specifications Nos 1 300 860, 1 223 734 and 1 671 035, by incorporating 40 tetravalent ions, such as, for example, Sn and Ti ions, which, with each tetravalent metal ion, render divalent, two iron ions which are initially trivalent, forming  $\text{Ti}^{4+}\text{Fe}_2^{3+}\text{O}_4$  and  $\text{Sn}^{4+}\text{Fe}_2^{3+}\text{O}_4$  in theory.

- The crystal anisotropy can be considerably influenced and thus the initial permeability temperature coefficient controlled by ions other than  $\text{Fe}^{2+}$ -ions, namely by cobalt ions.  
Each of these methods of controlling the temperature coefficient of the initial permeability, namely the use 45 of an extrastochiometric iron component, the substitution of part of the main components by tin and/or titanium, and the addition of cobalt, has already used to control the initial permeability temperature coefficient of manganese-zinc ferrites and results which are to some extent similar can be obtained with the different methods.

- It is an object of the present invention to provide a Sn and Ti-substituted, high or medium-permeability, low-loose, calcium containing manganese-zinc ferrite with an initial permeability temperature coefficient 50 which is substantially constant and positive, or which fluctuates only slightly about zero, over a wide temperature range, in particular between  $-60^\circ\text{C}$  and  $+100^\circ\text{C}$ , and which can therefore be used to produce components which are smaller than hitherto necessary, and which also contributes to a narrowing of the broad range of different types hitherto needed.

- 55 Surprisingly, it has been found that a suitable combination of the substitutes and additives already known and listed above brings about results that are very much better than those hitherto known, and, in particular that a very small addition of cobalt to a manganese-zinc ferrite already optimised as regards tin and titanium components allows the useful service temperature range to be further extended.

- According to the invention, there is provided a high permeability, low-loss calcium-containing manganese-zinc ferrite having a given initial permeability temperature coefficient that is constant and positive or fluctuates by only a small amount around zero over a wide temperature range, having a basic composition of:— 60

49 to 55 mol %  $\text{Fe}_2\text{O}_3$ ,

0.2 to 5 mol % of  $\text{SnO}_2$  and/or  $\text{TiO}_2$

- 65 remainder to 100 mol %,  $\text{MnO}$  and  $\text{ZnO}$ , and containing 0.03 to 0.4% by weight of the basic composition of

CaO and a very small amount of CoO selected in dependence on the theoretical  $\text{Fe}^{2+}$ -content of the ferrite determined by the proportion of Sn and/or Ti and extra-stoichiometric iron, so as to produce the given initial permeability temperature coefficient.

The amount of CoO present is preferably from 0.02 to 0.5% by weight.

- 5 An advantageous method of producing a ferrite according to the invention comprises the steps of forming a starting mixture of:  
 49 to 55 mol %  $\text{Fe}_2\text{O}_3$ ,  
 0.2 to 5 mol % ( $\text{SnO}_2 + \text{TiO}_2$ )  
 remainder to 100 mol %, MnO and ZnO  
 10 plus 0.02 to 0.5% by weight of the above components of CoO,  
 subjecting the mixture, if necessary to a prior heat treatment, grinding, adding 0.05 to 0.4% by weight of  $\text{CaCO}_3$ , pressing the ground material to form cores, heating the cores in a pure inert gas, in particular nitrogen, to the sintering temperature, in particular 1100 to 1300°C, sintering at this temperature in a nitrogen atmosphere containing oxygen and cooling in a nitrogen atmosphere under a decreasing partial pressure of  
 15 oxygen.

The invention will be further described with reference to the drawings, in which:—

Figures 1 and 2 are similarly graphs on the initial permeability  $\mu_i$  against temperature for two different basic ferrite formulations to show the effect of adding varying small amounts of CoO; and

- Figure 3 is a graph of the initial permeability against temperature for two different ferrites according to the invention to illustrate the formation of secondary maxima.

The possibility of controlling the initial permeability temperature coefficient in accordance with the invention by the inclusion of suitable amounts of CoO is illustrated in Figures 1 and 2.

The basic formulation of the ferrite of Figure 1 is:—

- 52.95 mol %  $\text{Fe}_2\text{O}_3$   
 32.60 mol % MnO  
 13.55 mol % ZnO  
 0.50 mol %  $\text{SnO}_2$   
 0.40 mol %  $\text{TiO}_2$   
 and that of the ferrite of Figure 2:—  
 52.43 mol %  $\text{Fe}_2\text{O}_3$   
 32.62 mol % MnO  
 13.55 mol % ZnO  
 0.50 mol %  $\text{SnO}_2$   
 0.90 mol %  $\text{TiO}_2$

- 35 The effect of the CoO content on the relationship between temperature and initial permeability is shown. For every +0.01% by weight of CoO, or 0.016 mol % of CoO, the secondary permeability maximum (i.e. the shoulder on the  $\mu_i(\theta)$  curve indicated by vertical arrows, is moved in the direction of decreasing temperature by about 7 to 10°C. To obtain the same movement of the secondary permeability maximum by the use of  $\text{Fe}^{2+}$ -ions would require about ten times as many  $\text{Fe}^{2+}$  ions as Co ions. It is thus possible to work in  
 40 accordance with the invention with extremely low iron values and still obtain a kink in the  $\mu_i(\theta)$  curve at a very low temperature. One advantage of this is that the disturbance phenomena occurring at high iron contents are avoided. An additional advantage of controlling the initial permeability temperature coefficient with the aid of Co ions lies in the fact that it is possible to work, not only with low iron contents, but also with low zinc contents i.e. at a higher Curie temperature, without the  $\mu_i(\theta)$  curve sagging between the high and low  
 45 temperature maxima. One reason for this may be a tertiary permeability maximum produced by the Co-ions as shown by ferrite A in Figure 3. This ferrite has been deliberately sintered so that the maximum, here at about +90°C, is clearly defined. Normally, however, the sintering will be carried out so that the ferrite has the curve shown by the broken line in Figure 3 where  $\alpha\mu$  is substantially constant over a wide temperature range. An example for this is ferrite B. Here  $\alpha\mu$  is so small, at  $0.4 \times 10^{-6}\text{K}^{-1}$ , that the effective permeability  $\mu$  can be  
 50 doubled if the same capacitor is used in the filter as when previously using materials with  $\alpha\mu = 0.8 \times 10^{-6}\text{K}^{-1}$ . In the present case, the smoothing of the  $\mu_i(\theta)$  curve was effected by moving the maxima marked I, II and III namely the Hopkinson or primary maximum, the secondary maximum and the tertiary maximum, close together so that there is no longer any waviness in the  $\mu_i(\theta)$  curve. The invention is illustrated by the following examples which illustrate in particular, the advantageous manner in which Co ions can be used in  
 55 extremely small amounts to control the temperature coefficient of (Sn + Ti)-substituted manganese-zinc ferrites, and how, at the same time, very low losses and a low level of variation are obtained.

#### Example 1

The following amounts of starting materials:—

- 51.5 mol %  $\text{Fe}_2\text{O}_3$   
 31.0 mol % MnO  
 16.5 mol % ZnO  
 0.5 mol %  $\text{SnO}_2$   
 0.5 mol %  $\text{TiO}_2$   
 65 plus 0.2 % by weight of CoO of the total weight of the above materials

were mixed for 2 to 4 hours in distilled water in a ball mill, subjected to a preliminary heat treatment at 850°C for one hour and then wet-ground for 2 hours whilst adding an amount of CaCO<sub>3</sub> which will produce about 0.06 % by weight of CaO in the final product. Annular cores were pressed from the dried mixture at 1 kBar and were heated in pure nitrogen gas, sintered at 1250 to 1300°C in a nitrogen atmosphere containing 2 to 4 % by volume of oxygen and then cooled in a nitrogen atmosphere with a falling oxygen partial pressure, 0.8 % by volume of oxygen remaining at 1100°C and not more than 20 ppm of oxygen being present at below 900°C.

The effect of temperature upon the initial permeability  $\mu$  is shown for this ferrite in Figure 3 (ferrite B). This highly permeable ferrite has a Curie temperature of 175°C and minimal loss coefficient over a wide temperature range together with a very constant positive temperature coefficient.

The technical characteristics of this ferrite are:

$$\mu = 3500$$

$$\tan \delta / \mu = 1.5 \times 10^{-6} \text{ at } 100 \text{ kHz}$$

$$= 0.8 \times 10^{-6} \text{ at } 20 \text{ kHz}$$

$$= 0.5 \times 10^{-6} \text{ at } 5 \text{ kHz}$$

$$\eta_B = 0.25 \times 10^{-6} / \text{mT at } 100 \text{ kHz}$$

$$= 0.15 \times 10^{-6} / \text{mT at } 20 \text{ kHz}$$

$$D/\mu = 2 \times 10^{-6}, 2 \text{ h} \dots 20 \text{ h, measured at } 60^\circ\text{C}.$$

The specific temperature coefficient  $\alpha/\mu$  is substantially constant and positive between -40 and +80°C and has a value of  $(0.4 \pm 0.05) \times 10^{-6} \text{K}^{-1}$ . Its value can also be adjusted to  $(0.7 \pm 0.1) \times 10^{-6} \text{K}^{-1}$  for the same temperature range by the use of more severe oxidation during cooling.

A material of the same composition but without the addition of CoO in accordance with the invention, has with otherwise analogous electrical properties:

$$\alpha/\mu = 0.2 \times 10^{-6} \text{K}^{-1} \text{ from } 20 \text{ to } 60^\circ\text{C and}$$

$$\alpha/\mu = (1.5 \text{ to } 2.5) \times 10^{-6} \text{K}^{-1} \text{ from } 20 \text{ to } -40^\circ\text{C, there thus being a sharp kink in the } \mu(v) \text{ curve.}$$

#### Example 2

A mixture of the following initial materials:—

50.55 mol % Fe<sub>2</sub>O<sub>3</sub>

32.25 mol % MnO

14.75 mol % ZnO

0.61 mol % SnO<sub>2</sub>

1.84 mol % TiO<sub>2</sub>

plus 0.05 % by weight of CoO

was subjected to the same preliminary treatment as described in example 1 and was combined with 0.1 % by weight of CaCO<sub>3</sub>. Pressings made from this mixture were then heated to 1150 to 1200°C in pure nitrogen gas, sintered at this temperature in a nitrogen atmosphere containing 1 to 2 % of by volume of oxygen and then cooled in a nitrogen atmosphere with a falling oxygen concentration such that at 1000°C there was still 180 ppm of oxygen present and at 900°C only 10 ppm of oxygen. The medium-permeability ferrite obtained in this way had the following technical characteristics:

$$\mu = 1600$$

$$\tan \delta / \mu = 1.1 \times 10^{-6} \text{ at } 100 \text{ kHz}$$

$$= 6.7 \times 10^{-6} \text{ at } 500 \text{ kHz}$$

$$\eta_B = 0.2 \times 10^{-6} / \text{mT (100 kHz)}$$

$$D/\mu = 3 \times 10^{-6} \text{ measured at } 60^\circ\text{C, between } 2 \text{ h and } 20 \text{ h}$$

$$\alpha/\mu = (0.45 \pm 0.05) \times 10^{-6} \text{K}^{-1} \text{ from } -20 \text{ to } +80^\circ\text{C}$$

A material of the same composition but without the proportion of Co has the following temperature coefficients with otherwise the same properties:

$$\alpha/\mu = 0.6 \times 10^{-6} \text{K}^{-1} \text{ from } 20 \text{ to } 80^\circ\text{C}$$

$$\alpha/\mu = (1.5 \dots 2.5) \times 10^{-6} \text{K}^{-1} \text{ from } 20 \text{ to } -40^\circ\text{C}$$

#### Example 3

A low-permeability material with the following initial composition:

51.4 mol % Fe<sub>2</sub>O<sub>3</sub>

33.1 mol % MnO

14.1 mol % ZnO

0.5 mol % SnO<sub>2</sub>

0.9 mol % TiO<sub>2</sub>

plus 0.15 % by weight of CoO

and 0.1 % by weight of CaCO<sub>3</sub>

was treated essentially in the same manner as in example 1. Sintering for 1–2 hours took place at 1150°C in a nitrogen atmosphere containing 1 % by volume of oxygen. Cooling was effected in a nitrogen atmosphere with the oxygen content falling constantly to less than 20 ppm at 900°C.

The ferrite thus produced had the following characteristics:

$$\mu = 1200$$

$$\tan \delta/\mu = 1.5 \times 10^{-8} \text{ (100 kHz)}$$

$$= 5.0 \times 10^{-8} \text{ (500 kHz)}$$

$$= 15 \times 10^{-8} \text{ (800 kHz)}$$

$$5 \quad \eta B = 0.4 \times 10^{-6} \text{ mT (100 kHz)}$$

$$D/\mu < 5 \times 10^{-6} \text{ at } 60^\circ\text{C, between 2 and 20h}$$

$$\alpha/\mu = (0.75 \pm 0.05) \times 10^{-6} \text{ K}^{-1} \text{ from } -40 \text{ to } +80^\circ\text{C}$$

Without the added Co in accordance with the invention, at room temperature with otherwise similar properties there is a sharp kink in  $\mu(v)$  curve with

$$10 \quad \alpha/\mu = 0.2 \times 10^{-6} \text{ K}^{-1} \text{ from } 20 \text{ to } 60^\circ\text{C}$$

$$\alpha/\mu = (1.5 \dots 2) \times 10^{-6} \text{ K}^{-1} \text{ from } 20 \text{ to } -40^\circ\text{C}$$

#### Example 4

Table 1 below shows with reference to substances 1 to 5 how the kink or maximum in the  $\mu(v)$  curve is moved to lower temperatures for a given formulation by the addition of increasing amounts of CoO (see Figure 2) while at the same time extremely low loss coefficients are achieved in the low temperature range (and at temperature above the maximum temperature). Thus materials are obtained which can be used, for example, together with zero temperature coefficient capacitors. For practical purposes, the best materials are those marked  $\beta 1$  to  $\beta 4$ . These are medium-permeability materials which can be used very satisfactorily up to frequencies of a few 100 kHz.  $\beta 0$  shows the properties of a material without the addition of CoO in accordance with the invention. The pressings used were made as in example 1. The cores were sintered at  $1190^\circ\text{C}$  in a nitrogen atmosphere containing 2.2 % by volume of oxygen. The cores were cooled in a nitrogen atmosphere with constantly decreasing oxygen partial pressure.

#### 25 Example 5

Table 2 shows the properties of materials which also have a temperature coefficient that fluctuates around zero with a permeability level of about 2000. The powder and pressings were made as in example 1. The materials were sintered at  $1200$  to  $1250^\circ\text{C}$  in a nitrogen atmosphere containing 2 to 4 %  $\text{O}_2$  and cooled in nitrogen with a decreasing oxygen content.

Table 1  
Medium—permeability materials with extremely low losses at low and normal temperatures  
and a temperature coefficient that fluctuates around zero over a wide temperature range

| Data<br>Materials | CoO<br>added<br>(% by<br>weight) | Main<br>components<br>(mol %)                 | Magnetic properties |   |   |                               |  |                             |   |       |        |       |
|-------------------|----------------------------------|---|---------------------|---|---|-------------------------------|--|-----------------------------|---|-------|--------|-------|
|                   |                                  |   | /ul                 | tan $\delta$ // ul<br>100kHz<br>200<br>(10-6) | tan $\delta$ // ul<br>in min.<br>100kHz<br>(10-6) | Temp. of<br>loss min.<br>(°C) | $\eta B$ ; 100kHz<br>10-6/mT<br>(10-6) | D // ul<br>60°C,<br>2h-20h. | $\alpha$ // $u_i$ / (10 <sup>-6</sup> K <sup>-1</sup> ) |       |        |       |
|                   |                                  |   |                     |   |   |                               |  |                             | 20.80   | 20.0  | -20.20 |       |
| $\beta$ 0         | 0                                | ) Fe <sub>2</sub> O <sub>3</sub> : 52.43<br>) | 1500                | 1.3   | 1.3   | + 30                          | 0.25                                   | $\leq 5$                    | 0.2   | 1.5   | 1.5    | 1.9   |
| $\beta$ 1         | 0.03                             | ) MnO : 32.62<br>)                            | 1490                | 1.25  | 1.0   | + 10                          | 0.25                                   | $\leq 5$                    | -0.003  | -0.12 | 0.5    | 1.18  |
| $\beta$ 2         | 0.06                             | ) ZnO : 13.55<br>)                            | 1440                | 1.34  | 1.0   | - 20                          | 0.30                                   | $\leq 5$                    | 0.06  | -0.5  | -0.44  | 0.12  |
| $\beta$ 3         | 0.09                             | ) TiO <sub>2</sub> : 0.90<br>)                | 1380                | 1.5   | 1.2   | - 40                          | 0.35                                   | $\leq 5$                    | 0.32  | -0.54 | -0.55  | -0.5  |
| $\beta$ 4         | 0.12                             | ) SnO <sub>2</sub> : 0.50<br>)                | 1275                | 1.6   | 1.2   | - 40                          | 0.40                                   | $\leq 5$                    | 0.5   | -0.02 | -0.22  | -0.20 |
| $\beta$ 5         | 0.15                             | )<br>)  | 1220                | 1.6   | 1.4   | - 30                          | 0.63                                   | $\leq 5$                    | 1.2   | 0.5   | 0.35   | 0.40  |

Table 2  
High—permeability materials with low loss coefficients over a wide temperature range  
and a temperature coefficient that fluctuates around zero over a wide temperature range

| $\delta$   | 0 | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   |
|------------|---|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| $\delta 0$ | 0 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 |
| $\delta 1$ | 0 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 |
| $\delta 2$ | 0 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 |
| $\delta 3$ | 0 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 |



## CLAIMS

1. A high or medium-permeability, low-loss calcium-containing manganese-zinc ferrite having a given initial permeability temperature coefficient that is constant and positive or fluctuates by only a small amount around zero over a wide temperature range having a basic composition of:  
49 to 55 mol %  $\text{Fe}_2\text{O}_3$ ,  
0.2 to 5 mol % of  $\text{SnO}_2$  and/or  $\text{TiO}_2$   
remainder to 100 mol %  $\text{MnO}$  and  $\text{ZnO}$  and containing 0.03 to 0.4% by weight of the basic composition of  $\text{CaO}$  and a very small amount of  $\text{CoO}$  selected in dependence on the theoretical  $\text{Fe}^{2+}$  - content of the ferrite determined by the proportion of  $\text{Sn}$  and/or  $\text{Ti}$  and extra-stoichiometric iron, so as to obtain the given initial permeability temperature coefficient. 5
2. A ferrite as claimed in claim 1 wherein the amount of  $\text{CoO}$  is from 0.02 to 0.4% by weight of the basic composition of the ferrite. 10
3. A ferrite as claimed in claim 1 substantially as hereinbefore described with reference to any of the 15 examples. 15
4. A method of producing a ferrite as claimed in claim 1 comprising the steps of mixing the starting materials for the basic composition and from 0.02 to 0.5% by weight of the weight of the basic composition of  $\text{CoO}$ , grinding the mixture, adding an amount of  $\text{CaCO}_3$  which will produce from 0.03 to 0.04% by weight of the weight of the basic composition of  $\text{CaO}$  on sintering, pressing the mixture to form cores, heating the 20 cores to a sintering temperature in a pure inert gas, sintering the cores at this temperature in an atmosphere of nitrogen containing oxygen, and cooling the sintered cores in a nitrogen atmosphere containing a continuously decreasing oxygen content. 20
5. A method as claimed in claim 4 wherein the mixed starting materials are subjected to a preliminary heat treatment before grinding.
6. A method as claimed in claim 4 or claim 5 wherein the cores are heated to the sintering temperature in 25 an atmosphere of pure nitrogen. 25
7. A method as claimed in any one of claims 4 to 6 wherein the cores are sintered at 1100 to 1300°C.
8. A method of producing a ferrite as claimed in claim 1 substantially as hereinbefore described with reference to any of the examples.